

7787035

08138445

Patent

Attorney's Docket No. 027500-386



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**UTILITY PATENT
APPLICATION TRANSMITTAL LETTER**

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

Enclosed for filing is the utility patent application of Paul W. DENT, Bengt PERSSON and Bjorn GUDMUNDSON for MOBILE ASSISTED HANDOVER USING CDMA.

Also enclosed are:

- ☒ 3 sheet(s) of ☐ formal ☒ informal drawing(s);
- ☐ a claim for foreign priority under 35 U.S.C. §§ 119 and/or 365 in ☐ a separate document ☐ the declaration;
- ☐ a certified copy of the priority document;
- ☐ an Associate Power of Attorney;
- ☐ _____ verified statement(s) claiming small entity status; and
- ☐ an Assignment document.

The declaration of the inventor(s) ☐ also is enclosed ☒ will follow.

The fee has been calculated as follows:

CLAIMS					
	NO. OF CLAIMS		EXTRA CLAIMS	RATE	FEE
Basic Application Fee					\$ 690.00
Total Claims	15	MINUS 20 =	-0-	x \$20 =	-0-
Independent Claims	5	MINUS 3 =	2	x \$72 =	144.00
If multiple dependent claims are presented, add \$220.00					-0-
Total Application Fee					834.00
If verified statement claiming small entity status is enclosed, subtract 50% of Total Application Fee					-0-
Add Assignment Recording Fee of \$40.00 if Assignment document is enclosed					-0-
TOTAL APPLICATION FEE DUE					834.00

- [X] A check in the amount of \$ 834.00 is enclosed.
[] Charge \$ _____ to Deposit Account No. 02-4800.

The Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§ 1.16, 1.17, and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800. A duplicate of this paper is enclosed.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS

By: Steven M. du Bois
Steven M. du Bois
Registration No. 35,023

The George Mason Building
Washington & Prince Streets
P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620

Date: April 17, 1992

3

834-1-A

07/870337
384456



UNITED STATES APPLICATION FOR
LETTERS PATENT

FOR

MOBILE ASSISTED HANDOVER USING CDMA

BY

Paul W. DENT, Bengt PERSSON and Bjorn GUDMUNDSON

BURNS, DOANE, SWECKER & MATHIS
The George Mason Building
Washington and Prince Streets
P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620

Attorney Docket No. 027500-386

RECORDED & INDEXED



BACKGROUND

In mobile radio telephone systems, the capability is provided to transfer the handling of communications with a mobile station from one base station to another, as the mobile station changes its position and so moves out of the coverage range of one base station and into the coverage area of another base station. This process is commonly termed handover or handoff.

To smoothly complete a handover, the network controlling the base stations must first determine, for each mobile station, whether the need for handover is imminent and secondly determine to which new base station handover should be effected. In making the latter decision it is desirable that the network controller know either how well each base station can receive signals from a mobile station in question, or how well the mobile station in question can receive signals from each base station, or both. The present invention provides a method for the base station to acquire this information using a code division multiple access (CDMA) transmission method.

Conventional mobile telephone systems were based largely on Frequency Division Multiple Access (FDMA), in which each mobile station transmits on a unique frequency within its current base station area. The mobile station is thus unaware of signals on other frequencies from surrounding bases. In FDMA systems it would be too costly to equip mobile stations with an extra receiver that could be used to scan other base frequencies. Instead, it is established practice that base stations are equipped with a scanning receiver that looks out for the signals of approaching mobile stations. The network then hands over a mobile from a base station covering an area it is leaving to the base station that

reports the best reception of the mobile station's signal.

More recent cellular telephone standards employ Time Division Multiple Access (TDMA) in which a fixed time period (e.g., 20 mS) on each radio frequency is divided into a number (e.g., 3) of short timeslots (e.g., 6.6 mS) that are cyclically used by different mobile stations. Thus, a first mobile station transmits in the first timeslot in each period, a second mobile station transmits in the second timeslot in each period and so on. Likewise the base station transmits to one mobile station in the first timeslot, another mobile station in the second slot and so on. By offsetting the allocation of timeslots in the two communications directions, base to mobile (the downlink) and mobile to base (the uplink), it can be arranged that a first mobile transmits in the first timeslot and receives in the second timeslot; a second mobile transmits in the second timeslot and receives in the third, while a third mobile transmits in the third timeslot and receives in the first timeslot. An advantage of this arrangement is that a mobile station does not need to transmit and receive simultaneously, which facilitates sharing a single antenna.

In the above three-timeslot example, each mobile station is active to transmit or receive in two of the three timeslots and idle in the remaining timeslot. Therefore it is possible for TDMA mobile stations to use this idle time to search for signals from other base stations and measure their signal strength. By reporting these signal strength measurements to the base station using a slow speed data channel multiplexed with the traffic (i.e., voice), the network is informed about the base stations each mobile station can receive. The network can use this information to effect handover to the best base station, and such a system is termed mobile assisted handover (MAHO). When the base stations scan

for the signal strength of mobile stations, the system could be termed base assisted handover (BAHO).

Systems providing MAHO also have access to the base station measurements, and so are able to effect smoother and more reliable handovers because both uplink and downlink signal strengths are taken into account, instead of just uplink strengths in the case of BAHO. However, these conventional systems have a number of limitations. For example, MAHO has conventionally only been used in TDMA systems. TDMA systems, however, involve a certain waste of capacity due to the need for guard spaces between timeslots during which the mobile stations' transmitters power up and down. Moreover, in these TDMA systems with MAHO, fast frequency switching is needed to scan channels on which other base stations are transmitting during the short idle periods, which is technically difficult and adds both complexity and cost to the system. The available time in the idle slot combined with the difficulty in switching frequency rapidly permit only one neighboring base frequency to be scanned per 20 ms frame. In FDMA systems, MAHO has not been implemented because base stations in FDMA systems use different frequencies to transmit control channels than those being used by mobile stations for transmissions and FDMA mobiles cannot change frequency without loss of traffic.

The present invention uses Code Division Multiple Access (CDMA) to permit neighboring base stations to share the same frequency channel, and thus permit the mobile to assess their signal strength without changing frequency or losing traffic. Another feature of the present invention is that the signals generated by the neighboring base station to which the mobile station is being handed over comprise a diversity transmission which can be combined with the transmissions from the base station originally connected to the mobile station to improve reception quality.

Conventionally, such diversity transmissions have been provided in CDMA systems by transmitting a signal which is encoded and modulated in exactly the same way as the original signal with a relative delay of one or more chips or bits. These overlapping signals can then be combined in an echo-integrating type of receiver such as a Viterbi equaliser or a RAKE receiver.

A disadvantage of these conventional macrodiversity systems is the need to transmit from one base station the codes that are allocated being used to transmit to the mobile station to one or more other base stations. In a subtractive CDMA system, this also involves informing all of the mobile stations in a cell when a diversity transmission for any mobile is initiated of the exact code that will be used.

This problem is overcome according to the present invention by using different codes for the diversity transmissions so that an originally connected base station need not transmit an allocated code to other base stations. This takes advantage of the fact that a CDMA mobile receiver is able to simultaneously receive and decode both its normally coded signal and the diversity coded signal.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, features, and advantages of the present invention will become more apparent by reading the following detailed description in conjunction with the drawings in which:

Figure 1 illustrates a block diagram of a transmitter/receiver according to the present invention;

Figure 2 illustrates the control unit of Figure 1 in more detail; and

Figure 3 shows a network control system for performing handovers between base stations according to the invention.

DETAILED DESCRIPTION

checked
11-31-92
NV
5
No. 5, 151,914
No. 07/628,359, entitled "CDMA Subtractive Demodulation"
which was filed on December 17, 1990 and is hereby
incorporated by reference. However, those skilled in the
art will readily appreciate that the present invention is
applicable to any system in which adjacent base stations
operate on the same frequency and use signals with coded
features enabling them to be distinguished.

In the above mentioned application, a system is
described in which coded signals are scrambled with
unique scrambling codes and then transmitted on the same
frequency. A plurality of overlapping signals received
on a single frequency channel include a number of signals
within the same cell as well as a number of signals
transmitted from base stations in neighboring cells.
Despite overlap in time and frequency, individual signals
can be selected for decoding by first descrambling the
received signal with the appropriate scrambling code and
then decoding the underlying information bearing code.
Undesired interfering signals do not descramble to a form
that correlates with the decoding and so are suppressed
to a certain degree called the processing gain. An
exemplary underlying information coding is bi-orthogonal
or orthogonal coding using Walsh-Hadamard functions. The
suppression of interference caused by the other signals
transmitted on the same frequency is enhanced by the
subtractive CDMA demodulation system disclosed in the
aforementioned patent application by descrambling and
decoding signals in signal strength order from strongest
to weakest and subtracting each signal from the received
composite signal as it is decoded. In that way, stronger
signals do not substantially interfere with weaker ones

The general arrangement of an exemplary transmitter/receiver according to the invention is shown in Figure 1. A CDMA decoder 10 receives a composite signal via an antenna 11, suitable amplifying, filtering and downconverting by signal processing circuitry 12 and A to D converter 13. The A to D converter 13 produces complex number outputs and can operate, for example, according to the logpolar principle described in U.S. Patent No. 5,048,059, which is hereby incorporated by reference. The CDMA decoder is programmable by means of control unit 14 with any of a number of unique descrambling codes corresponding to the overlapping signals contained in the composite received signal. These descrambling codes are presented to the decoder in descending order of signal strength of the associated signal. The decoder furnishes decoded information and signal strength measurement information back to the control unit. Signal strength information can include amplitude and phase information, not only for the direct ray received from any station but also for delayed echoes. The direct ray and echo information is processed, for example by filtering and summing, to determine the total received energy in each signal. If signals are detected to have altered their position in signal strength sorted order, or are predicted to be about to do so, the control unit can alter the order of decoding in the next period. Decoded information contained in at least one of the decoded signals informs the control unit about the scrambling codes and/or frequencies of the cell from which that signal was generated and/or the codes and frequencies of neighboring cells. Similarly, outgoing traffic is encoded by CDMA encoder and modulator 19, upconverted for transmission by upconverter 15 and amplified by power amplifier 16 before being transmitted from antenna 11. The output power

0364-4074/96/0005-0000\$05.00/0

level can be controlled by control unit 14 at both the encoder 19 and power amplifier 16 over control bus 18. The control unit 14 can also perform frequency programming for both received signals and transmission signals over control bus 9.

One way in which these scrambling codes can be constructed is to bitwise modulo-2 add one of a number (e.g. 7) of base station ID codes to one of a number (e.g. 32) of traffic channel ID codes, as described in U.S. Patent Application Serial No. 01/King 8165, entitled "Multiple Access Coding", which was filed on April 10, 1992 and is hereby incorporated by reference. Moreover, one of the traffic channel ID codes can be reserved in each cell for use as a broadcast channel, calling channel or pilot channel as described in U.S. Patent Application Serial No. 08/204,470, entitled "Calling Channel in CDMA Communications System", filed on April 13, 1992 and is hereby incorporated by reference. The signal using this code is always the strongest signal so the mobile receiver knows it shall attempt decoding of that signal before any other signals from the same cell.

The seven base station ID codes can be allocated to cells in a so-called 7-cell pattern such that no two adjacent cells use the same ID code. However, the use of codes will generally be repeated two cells or more away, so there can be ambiguity due to propagation anomalies as to whether a signal decoded using a particular code is from an adjacent cell or further away. Upon successfully decoding a broadcast channel, further information is obtained on the station ID to resolve this ambiguity. An advantage of restricting the number of base station ID codes is that the receiver only need attempt decoding with this limited number of codes, thereby accelerating the decoding process.

Normally, a receiver only need decode and subtract signals in descending signal strength order

JMS
checked
p. 16-83
10
patent
5, 353, 352
dec 86
9-16-93 15
5, 377, 183
C
Int'l

until it decodes its own traffic channel. If the mobile station is near the edge of its cell and thus possibly about to require handover to an adjacent cell, its traffic signal will be one of the stronger signals demodulated early, as will the calling channel of an adjacent cell, so it is not necessary to decode many signals in order to acquire the desired information. If, on the other hand, the mobile station is near the center of its own cell, the base station will allocate less downlink power to signals sent to the mobile and its signal will be among the weaker ones received. When this situation arises, the mobile station can deduce that it is not on the edge of its current cell and thus not about to require handover.

The mobile station can nevertheless attempt to demodulate the calling channel of a neighboring cell, even when the signal strength of such a calling channel is below that of the mobile station's traffic channel, by continuing to decode received signals after extracting its own traffic signal. In this way, the system can predict when the received signal strength of a relatively strong calling channel of a neighboring base station will exceed the signal strength of the mobile station's own signal, so that the stronger signal will be subtracted first.

When the mobile receiver detects from relative signal strengths that it is nearing a point where a handover might be appropriate, the base station is informed by data message from the mobile station about the other base stations the mobile station can hear and their relative signal strengths. This process of signal strength reporting can also be continuous even when handover is not imminent. In order for such control-type messages not to interrupt traffic flow, it is conventionally known to multiplex a low bit rate data stream called the Slow Associated Control Channel (SACCH) with the higher bit rate traffic. It is also possible,

if the need for handover becomes more urgent, to steal capacity from the traffic channel to send a high priority message. Conventionally, such a priority message channel is known as a Fast Associated Control Channel (FACCH).

5 In exemplary embodiments of the present invention, the base station or fixed network includes processing circuitry to decide, for each mobile station, when handover is necessary and to implement handover at such times. At least three forms of handover can be
10 executed by a mobile station under control of the intelligent network controller as follows.

 A first form, called an internal handover, occurs when the network decides to keep the mobile station connected to its current base station for traffic
15 sharing or capacity optimization reasons, but to switch transmissions from the mobile station to another frequency or code. If a frequency change is commanded, a slight interruption in traffic will occur while the mobile station acquires synchronization on the new
20 frequency.

 A second form of handover is the transfer of a mobile station to another base station without a frequency change. This handover has the potential to be a so-called glitch-free or seamless handover that
25 involves no interruption of traffic whatsoever. In fact, as discussed below, according to one exemplary embodiment of the invention a single mobile receiver establishes reception of the new base station before relinquishing the signal from the old base station. During this period
30 where the mobile station is receiving its intended signal from both base stations, the receiver can use both decoded signals to obtain diversity gain. This type of system is also known as soft handover, macro-diversity, or transmit space diversity.

35 To establish communication with the second base station, the second base station is informed by the network to begin transmitting a signal for the mobile

2025 RELEASE UNDER E.O. 14176

station. Since it could be disturbing for other mobile receivers already connected in the new cell if a new signal suddenly appeared as one of the higher signal strengths, the new signal is preferably slowly ramped up from a lowest signal strength to a desired power level. This process can also be used when a call is set up from scratch and is known in this context as random access. Until handover is complete, the old base station remains in control of the mobile station's behavior, particularly with respect to controlling the mobile station's transmitter output power. In implementing power control during macro-diversity or soft handover, the controlling base station can receive information from the other base station or stations regarding the signal strength with which they receive the signal transmitted from the mobile station. Completion of handover occurs when control of the mobile station, including the power control function, is transferred from the old base to the new base. Macro-diversity operation can continue for a while, with the new base now as the master and the old base as the slave, until the mobile station is no longer at the boundary of the two cells and the old base station is informed that it can terminate transmission to that mobile, thereby releasing the code which can then be used for establishing a new call. As the sudden disappearance of a signal among the strongest could also disturb ongoing traffic, the signal is preferably ramped slowly down to a minimum power level before being turned off.

A third type of handover that can be effected is a frequency change upon changing base station. In this case, a seamless handover or macro-diversity operation cannot be achieved unless an internal handover of the first-described type had previously been made to the new frequency. The latter is preferable, but may not always be possible depending on the traffic load on the various frequencies in the two cells. Frequency and code allocation algorithms can be provided that attempt to

distribute these resources to mobile stations according to position so as to achieve desirable loading patterns. Using such algorithms an advantage is provided by means of CDMA coding permitting many calls to take place on the same frequency, so that the mean time between new call set-up or clear-down requests is reduced to a few seconds. It then becomes possible for a handover system to request reservation of capacity on any frequency for use by a mobile station that is about to enter the cell, and such a request will normally be granted within a few seconds. The intelligent network controller also strives at call set-up to allocate frequencies so as to even out the loading on each frequency channel. Frequencies can be allocated or re-assigned by means of internal handovers based on which channel will suffer the least from interference from more distant stations. Using such adaptive channel allocation, the network can effectively transfer capacity on any channel from surrounding cells having light demand to a cell with a peak demand, thus achieving averaging of capacity demand over more than one cell, which provides an increase in useable capacity without risk of momentary overload becoming unacceptable.

The implementation of these above-described types of handovers according to the present invention is effected in the mobile station by control unit 14. Further details of control unit 14 are illustrated in Figure 2. Demodulation results are fed from the CDMA decoder 10 to a demultiplexer or selector 20 in control unit 14. The demultiplexer is controlled by the control processor 23 to select either only data from the current base station with which the mobile station is in communication or data from both the current base station and a new base station to which handover is imminent. Selected data is fed to the traffic decoder 22 and the message decoder 21 which are also controlled by the control processor 23 to accept either data only from the current (old) base station or from both the old and new

base stations. The message decoder 21 processes selected data so as to reduce transmission errors using both error correction decoding and diversity combination techniques and passes decoded messages to control processor 23.

5 These messages indicate to the control processor 23 whether the mobile station shall operate in normal mode, (i.e. decoding traffic and messages from the current base station only), whether it shall operate in diversity mode, (i.e. decoding messages and traffic based on data
10 received from the current base and another base station), or whether the mobile station shall execute a frequency change or transmit code change. Similarly, the control unit includes a message encoder 24 and a traffic encoder 25 for outgoing transmissions. The control processor 23
15 selects an output from either of these encoders by way of multiplexer 26 which is sent to the CDMA encoder/modulator 19.

The preferred type of handover is the above-described soft handover which does not involve even a
20 momentary loss of traffic. The operation of a receiver in executing soft handovers according to the present invention will now be described.

A control message is transmitted from the current base station to the mobile station, indicating
25 the CDMA code that a neighboring base station will use to transmit data to the mobile station. This is processed in control unit 14 as further detailed in Figure 2 causing the mobile receiver to look for and demodulate the signal from the new base station. Because it is
30 undesirable to suddenly start new transmissions at a high power level, the new base station preferably starts transmitting to the mobile at low power and gradually increases the power level to a predetermined value. The mobile station continues for the time being to transmit
35 using the original CDMA code, but includes data indicating how well it is receiving the new base station. When the old base station determines from this data that

the mobile station is receiving the new base station transmission sufficiently reliably, the old base station initiates a message instructing the mobile station to regard the new base station as its current base station. 5. The old base station can then cease transmission using the original CDMA code. Because it is undesirable to suddenly terminate a high power transmission, the old base station preferably gradually reduces the power level of that CDMA code transmission to a low power level 10 before ceasing transmission and returning that code to a pool available for establishing new communications.

The operation of the mobile transmitter during soft handover is preferably analogous to that of the base station network. Initially, the mobile station continues 15 to transmit using its original CDMA code. The current base station informs the new base station to look for and demodulate the mobile station's transmission using this code. When employing subtractive CDMA demodulation in which all signals are demodulated and subtracted in 20 signal strength order, the new base station would most likely already have been demodulating the mobile signal. The new base station can exchange demodulated data with the old base, for the purposes of using the data diversity to obtain better error correction decoding. 25 This exchange preferably takes place by means of fiber-optic data links between the base stations, carrying multiplexed data pertaining to a plurality of mobile stations, but can also take place via any other type of communication links such as coaxial landlines, 30 trunks or dedicated microwave radio data links.

When the mobile station receives a message from its old base station notifying it to regard the new base station as its current base station, the mobile station starts transmitting to the new base station using the new 35 base station's CDMA code. Since it is undesirable to start a transmission suddenly at high power, the mobile station preferably ramps up the power level of the new

code from a low power level to the desired power level. The desired power level can, for example, be determined according to the method disclosed in U.S. Patent Application Serial No. 07/966,524, entitled "Duplex Power Control" which was filed on April 10, 1992 and is hereby incorporated by reference. Therein, the power level is adjusted based on the relative signal strength the mobile station receives on its code from the new base station compared to other codes from that base station.

10 A preferred modulation method is a linear modulation method including both amplitude and phase modulation for best spectral containment. The mobile transmitter power amplifier for such modulation is thus of linear type, such as class-A, class-B or class-AB.

15 Such an amplifier is not constrained to being able to transmit only one CDMA coded signal, but is able to transmit a plurality of superimposed signals, so long as their sum never exceeds the amplifier peak power capability. This ability can be employed by the mobile transmitter to permit initiation of transmission to the

20 new base station using a new access code before terminating transmission to the old base station using the old access code. Since sudden termination of transmission using the old code is undesirable, the

25 mobile station can gradually reduce the power level of transmission using the old CDMA code at the same time as it gradually increases the power level of transmission using the new code, in such a way that the sum of the two signals never exceeds the peak power capability of the

30 transmitter. At the crossover point where both superimposed transmissions are of equal power, the peak signal amplitude of each must be halved for the sum never to exceed unity, and the power in each transmitted code signal is thus 1/4. The total power transmitted from the

35 mobile station is thus halved, but since both base stations receive transmissions using both codes, quadruple diversity is in effect provided, more than

compensating for this 3dB reduction in mobile power. For this reason, it can be advantageous to prolong the period during which soft handover is in operation as long as a mobile station is near the edge of two cells. This mode of operation can be termed macrodiversity, and takes advantage of the CDMA receiver's ability to receive two or more CDMA codes simultaneously bearing the same information, and, conversely, the mobile CDMA transmitter's ability to transmit two CDMA coded signals bearing the same information.

When handover requires a frequency change because the new base station cannot provide a signal for the mobile station on the old frequency, it is not as feasible to achieve a handover without interruption of traffic flow. This is partly due to cost constraints in fabrication of the mobile station which dictate that only one frequency synthesizer be used jointly by both the transmitter and receiver. Given this limitation, it is not possible for the transmitter and receiver to change frequency at different times. If, on the other hand, two synthesizers are considered acceptable from a cost standpoint, the receiver frequency could be switched at a time when the downlink side of the conversation is silent, and the transmit frequency could be switched at a time when the uplink side of the conversation is silent.

In situations where a mobile station has a single frequency synthesizer it is, of course, desirable to take advantage of an opportunity to switch frequency when both sides of the conversation are silent. If this is not possible, however, the least perceived disruption in a conversation will occur if the frequency is switched just at the time one side or the other of the conversation becomes silent, as there can be a delay before the other party commences talking.

If such an opportunity does not arise before handover becomes urgent however, a handover is forced by transmitting from the current base station a channel

change command to the mobile in place of speech traffic, the channel change command being a data message containing details of the frequency, new base station ID and new CDMA traffic code that the mobile station shall use. The mobile station then terminates transmission on the old frequency during a pause in conversation as described above, changes frequency, and then starts transmission on the new frequency. Meanwhile, the new base station is informed by the old base station to expect the mobile station's signal. In the event that both base stations are able to receive on both the old and new frequencies, space diversity reception, as previously described, can be provided on both the old and new frequencies to improve reception quality while the mobile station is in the handover region.

There is no point in the old and new base stations transmitting to the mobile station simultaneously on different frequencies however, as the mobile station, in contrast to the base station, is only equipped to receive on one frequency at a time. Ramping up the power level of the transmission from the new base using the new CDMA code can nevertheless be done before, or in parallel with, ramping down the power level of the old transmission so that both will in fact overlap for a short while and the interruption in traffic as the mobile changes frequency is not unnecessarily prolonged by having to wait for the new base station's transmission to appear.

A base station network for implementing handover as described above is illustrated in Figure 3. A first base station 32 having an antenna system 30 and a

CDMA transmitter/receiver system 31 is connected by communications links, for example fiber-optic lines, to one or more base station controllers 36. A second base station 35, having an analogous antenna 33 and transmitter/receiver 34, to which a mobile station in communication with the first base station will now communicate is also connected by similar links to the base station controller.

The base station controller can simply switch data through from one base to another under command of a switching center. If the controller operates in this manner, the diversity combination described above can be implemented in the first or second base station or both. Alternatively, the base station controller itself can perform the diversity combination or selection of data from two or more base stations. Moreover, error correction decoding subsequent to diversity combination can reside at base stations 32 and 35, at base station controller 36, or at the switching center. Likewise any digital speech decoding subsequent to error correction decoding can reside in any of these locations.

While the present invention has been described with reference to exemplary embodiments thereof, these exemplary embodiments are intended to be merely illustrative of the present invention rather than limitative. For example, although the above-described exemplary embodiments have been described in terms of mobile stations, the present invention can be implemented using any type of remote station (e.g., portable units). Moreover, while these exemplary embodiments implement macrodiversity using two differently coded CDMA transmissions in the context of the handover process, those skilled in the art will appreciate that such diversity transmissions can be provided during any stage

of CDMA communication, including normal traffic communication. Thus, the present invention encompasses any and all modifications which are within the spirit and scope of the present invention as set forth in the appended claims.

5

01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

WHAT IS CLAIMED IS:

5 1. In a cellular mobile radio communications system including at least one mobile station and at least two base stations, a method of transferring communication with said mobile station from a first to a second of said base stations comprising the steps of:

10 transmitting a signal on a first frequency from said first base station to said mobile station using a waveform encoded with a first code;

sending a transfer indication from said first base station via a fixed network to said second base station;

15 upon receipt of said transfer indication, transmitting a signal on said first frequency from said second base station to said mobile station using a waveform encoded with a second code; and

20 receiving at said mobile station said signals transmitted on said first frequency from said first and second base stations and decoding said signals using said first and second codes to produce a first and second demodulated signal.

25 2. In a cellular mobile radio communications system including at least one mobile station and at least two base stations, a method of transferring communication with said mobile station from a first to a second of said base stations comprising the steps of:

30 transmitting a control signal on a first frequency from said first base station to said mobile station using a waveform encoded with a first code to inform said mobile station of a second frequency and second code;

35

sending a transfer indication from said first base station via a fixed network to said second base station;

5 upon receipt of said transfer indication, transmitting a signal on the second frequency from said second base station to said mobile station using a waveform encoded with the second code; and

10 upon receipt by said mobile of said control signal, receiving said signal on said second frequency and decoding it with said second code to produce a demodulated signal.

See B2
15 3. A method according to claim 1, wherein said first code includes a first base station code combined with a first access code and said second code includes a second base station code combined with a second access code.

20 4. The method according to claim 1, further including the step of:
error correcting said demodulated signals.

See B3, B4
25 5. The method according to claim 4, wherein said error correcting step comprises performing diversity selection of symbols from said first and second demodulated signals.

See B4
30 6. The method according to claim 4, wherein said error correcting step comprises performing diversity combination of said first and second demodulated signals.

See B5
35 7. In a cellular mobile radio communications system including at least one mobile station and at least two base stations, a method of transferring communication with said mobile station from a first

to a second of said base stations comprising the steps of:

5 decoding, at said mobile station, signals received simultaneously from said at least two base stations on a first frequency and quantifying their relative signal strengths;

 transmitting a signal from said mobile station indicating said relative signal strengths;

10 receiving at one of said at least two base stations said signal indicative of signal strengths and sending said signal to a network controller; and

 processing said indicated signal strengths in said network controller and selecting one of said at least two base stations to maintain communication with said mobile station.

15 8. A method according to claim 7, wherein said network controller commands said selected base station to initiate a transmission to said mobile station using an available access code.

20 9. A method according to claim 7, wherein said access code is composed of a base station code combined with a traffic channel code.

25 10. In a cellular mobile radio communications system including at least one mobile station and at least two base stations, a method of transferring communication with said mobile station from a first
30 to a second of said base stations comprising the steps of:

 transmitting traffic on a first frequency from said first base station to said mobile station using a waveform encoded with a first code;

35 transmitting a control message on said first frequency from said first base station to said

mobile station using a waveform encoded with a second code;

5 sending a transfer indication from said first base station via a fixed network to said second base station;

upon receipt of said indication, transmitting a signal on said first frequency from said second base station to said mobile station using a waveform encoded with a third code; and

10 receiving at said mobile station said signals transmitted on said first frequency from said first and second base station and decoding these signals using said first, second and third codes to obtain a first demodulated traffic signal, a decoded control message and a second demodulated traffic signal.

15 11. A method according to claim 10, wherein said first code includes a combination of a first base station code with a first traffic channel access code and said second code includes combination of said first base station code with a control channel code.

20 12. A method according to claim 11 in which said third code includes a combination of a second base station code with a second traffic channel code.

25 13. A method according to claim 11 in which said third code includes combination of a second base station code and a control channel code.

30 14. A cellular mobile radio telephone system using Code Division Multiple Access to facilitate handover between a first and second base station comprising:

35 antenna, filtering, amplifying and downconverting means for producing an analog signal representative of

ORIGINAL
RECEIVED
JAN 11 1988
FBI - NEW YORK
B7

8553
#2

signals received from said first and second base station on the same frequency;

analog to digital conversion means for converting said analog signal to a sequence of numerical values;

CDMA processing means for processing and decoding said numerical values using a first and second code to obtain demodulated data signals received from said first and second base station transmitters and measurements of their relative signal strengths or qualities;

encoding means to encode said signal strength or qualities into a data message; and

CDMA transmitting means to transmit said data message.

15. A mobile station according to claim 14, wherein said first code includes combination of a first base station code with a first access code and said second code includes combination of a second base station code with a second access code.

15
Sub
B9

add
81
Add
J1
Add
L4



ABSTRACT

5 A method and system for facilitating handover
in mobile radio communication systems are ^{illustrated} disclosed. The
mobile unit assists in making handover decisions by
monitoring the signal strength of control channels
transmitted by base stations in neighboring cells.
During the handover, the mobile station can receive the
same information from and/or transmit the same
10 information to a plurality of base stations to provide
diversity combination and improve transmission quality.

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202

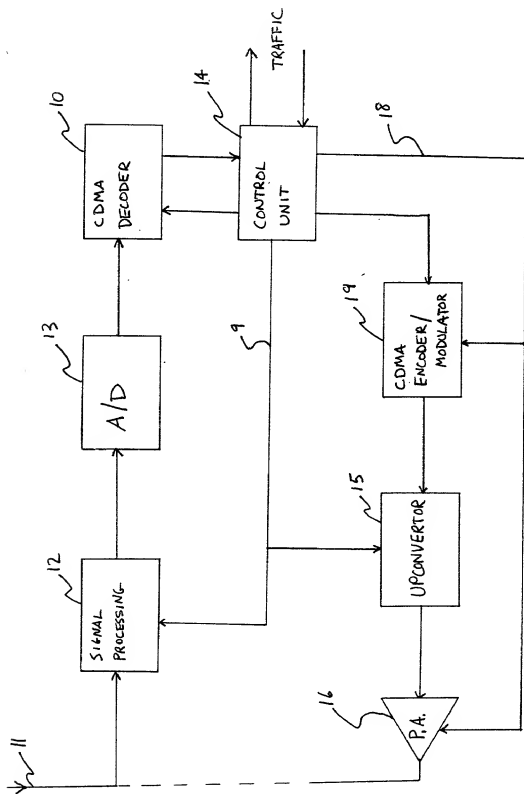


Fig. 1

FIGURE 2: CONTROL UNIT IMPLEMENTING THE
INVENTION

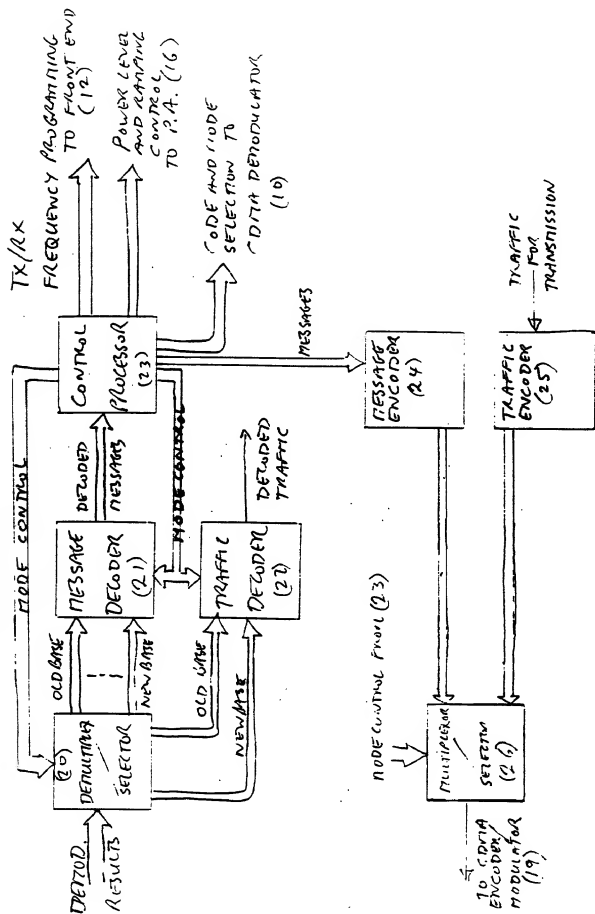
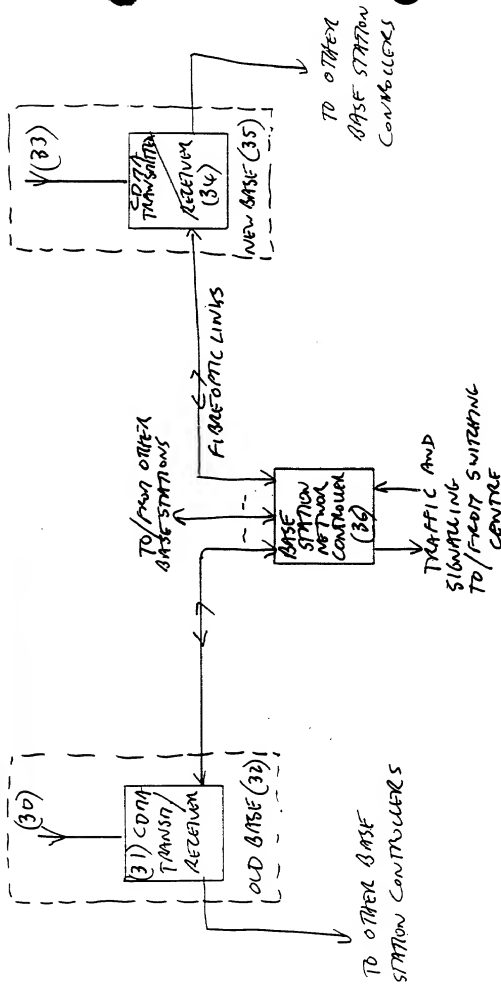


Figure 3: BASE STATION NETWORK ACCORDING TO THE INVENTION.





#3

DECLARATION AND POWER OF ATTORNEY
FOR UTILITY PATENT APPLICATION

Attorney Docket No.

027500-386

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I BELIEVE I AM THE ORIGINAL, FIRST AND SOLE INVENTOR (if only one name is listed below) OR AN ORIGINAL, FIRST AND JOINT INVENTOR (if more than one name is listed below) OF THE SUBJECT MATTER WHICH IS CLAIMED AND FOR WHICH A PATENT IS SOUGHT ON THE INVENTION

ENTITLED: MOBILE ASSISTED HANDOVER USING CDMA

the specification of which

(check one)

☐ is attached hereto;☒ was filed on April 17, 1992 as

Application Serial No. _____

and was amended on _____ ;
(if applicable)

I HAVE REVIEWED AND UNDERSTAND THE CONTENTS OF THE ABOVE-IDENTIFIED SPECIFICATION, INCLUDING THE CLAIMS, AS AMENDED BY ANY AMENDMENT REFERRED TO ABOVE;

I ACKNOWLEDGE THE DUTY TO DISCLOSE INFORMATION WHICH IS MATERIAL TO THE EXAMINATION OF THIS APPLICATION IN ACCORDANCE WITH TITLE 37, CODE OF FEDERAL REGULATIONS, Sec. 1.56 (a) which states: "A duty of candor and good faith toward the Patent and Trademark Office rests on the inventor, on each attorney or agent who prepares or prosecutes the application and on every other individual who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application. All such individuals have a duty to disclose to the Office information they are aware of which is material to the examination of the application. Such information is material where there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent. The duty is commensurate with the degree of involvement in the preparation or prosecution of the application.";

I do not know and do not believe the said invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to said application; that said invention was not in public use or on sale in the United States of America more than one year prior to said application; that said invention has not been patented or made the subject of an inventor's certificate issued before the date of said application in any country foreign to the United States of America on any application filed by me or my legal representatives or assigns more than twelve months prior to said application;

I hereby claim foreign priority benefits under Title 35, United States Code Sec. 119 and/or Sec. 365 of any foreign application(s) for patent or inventor's certificate as indicated below and have also identified below any foreign application for patent or inventor's certificate on this invention having a filing date before that of the application(s) on which priority is claimed:

COMBINED DECLARATION AND POWER OF ATTORNEY		Attorney Docket No. 027500-386	
COUNTRY/INTERNATIONAL	APPLICATION NUMBER	DATE OF FILING <small>(day, month, year)</small>	PRIORITY CLAIMED
			YES ___ NO ___
			YES ___ NO ___

I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:

William L. Mathis	-17,337	Frederick G. Michaud, Jr.	26,003	E. Joseph Gess	28,510
Peter H. Smolka	15,913	Alan E. Kopecki	25,813	David D. Reynolds	29,273
Robert S. Swecker	19,885	Regis E. Slutter	26,999	R. Danny Huntington	27,903
Platon N. Mandros	22,124	Samuel C. Miller, III	27,360	Eric H. Weiblast	30,505
Benion S. Duffett, Jr.	22,030	Ralph L. Freeland, Jr.	18,110	James W. Peterson	26,057
Joseph R. Magnone	24,239	Robert G. Mubai	28,531	Teresa Sianek Rea	30,427
Joel M. Freed	25,101	George A. Howance, Jr.	28,223	Robert E. Krebs	25,885
Norman H. Stegno	22,716	James A. LaBarre	28,632	Lance W. Chandler	29,467
Ronald L. Grudziecki	24,970				

and: _____

Address all correspondence to: Ronald L. Grudziecki
Burns, Doane, Swecker & Mathis
George Mason Building
Washington and Prince Streets
P.O. Box 1404
Alexandria, Virginia 22313-1404

Address all telephone calls to: Ronald L. Grudziecki at (703) 836-6620.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF SOLE OR FIRST INVENTOR Bengt Yngve Persson	SIGNATURE <i>Bengt Yngve Persson</i>	DATE 1992-05-20
RESIDENCE S-182 51 DJURSHOLM, Sweden		CITIZENSHIP Swedish
POST OFFICE ADDRESS Box 42 182 51 DJURSHOLM, Sweden		
FULL NAME OF SECOND JOINT INVENTOR, IF ANY Björn Gudmundson	SIGNATURE <i>Björn Gudmundson</i>	DATE 1992-05-20
RESIDENCE S-191 71 SOLLENTUNA, Sweden		CITIZENSHIP Swedish
POST OFFICE ADDRESS Örsavägen 13, S-191 71 SOLLENTUNA, Sweden		
FULL NAME OF THIRD JOINT INVENTOR, IF ANY Paul Wilkinson Dent	SIGNATURE <i>Paul W. Dent</i>	DATE 1992-06-05
RESIDENCE c/o Ericsson GE Mobile Communications Inc.		CITIZENSHIP British
POST OFFICE ADDRESS P.O. Box 13969, Research Triangle Park NC 27709 USA		

☐ Please see attached continuation page for additional inventors.